

Color Management for Web Browsers

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Chapter 1 - Introduction

The Internet has become one of the best places for an artist to showcase their work. Unlike traditional physical art galleries, the Internet is available to anyone with a computer and a network connection. The rest of the world now has access to the artist's work. This gives the artist opportunities to gain more recognition for their art and even make careers for themselves by selling their work over the Internet. Stock photo and image websites such as Stock.XCHNG and iStockPhoto allow consumers to browse stock photographs and photographers to reach a broader range of customers. A link or a file can simply be sent to potential clients and saves time and cost in comparison to using the postal service or a package delivery service. Patrons no longer need to travel to a specific place to view art, but can instead browse from the comfort of their home or office. An artist's online portfolio is also limitless in size and easily organized for all to see. Works can be arranged from earliest to latest submissions, or by subject, and can be found through a search feature. Many online galleries such as Flickr, a subsidiary of Yahoo! and DeviantArt, also function as communities. On these websites, artists can exchange ideas, information, and receive feedback on their work. It also allows the general public to easily find their art. Displaying their work on the Internet provides the artist with the opportunity to share and grow.

However, there are downfalls to using the Internet to create a portfolio. In a traditional art gallery, the lighting and environment are easily controlled. By installing the correct light fixtures and controlling any natural lighting, the art can be seen exactly as the artist desires. Patrons will all see the art precisely the same way and in the way the artist intends for them to see it. On the Internet, a number of variables can change the way images are perceived. Personal preferences

can be a large consideration. Screen brightness, resolution, and the type of monitor used can all affect the way that someone sees an image on the screen. One of the most important decisions that determine how an image is viewed is the web browser being used to view it. Different browsers have different color control settings, or lack them altogether. This can cause the colors of the image to be different from what the artist sees and can cause photographs to look washed out or too saturated.

This study asks the question: What are the best methods to ensure that the quality of images is the best on the Internet? The study must take into account many considerations including personal preferences, which browsers are most often used by consumers, and the abilities of the browsers themselves. For the average computer user, the color of an image on the Internet is not of the utmost importance. However, to artists and photographers, this is a crucial part of being successful. There is no way to guarantee an image will always look the same; yet, it is important for an image to always look good. The use of embedded color profiles can be beneficial. However, if a browser does not support embedded color profiles, other color settings will have to be used during the creation of the image.

The purpose of this study is to develop knowledge about different browser capabilities as they pertain to color management, as well as to formulate techniques to color manage images for use on the Internet. With the variety of open-source and proprietary browsers available to consumers today, it is a challenge to be able to know exactly how an image will look on each browser. Much in the same way that certain browsers may not support website elements such as Adobe Flash, certain browsers may not be able to reproduce color as well as others. However, browsers are constantly being improved, and their capabilities expand with every new version. It

is important to know which browsers are best for viewing images and which browsers will need improvement. It is also important to know what options in programs such as Adobe Photoshop and Adobe Illustrator can extend an image's potential on the web and how to correctly implement them. Using these tools, an artist can at least be aware of how images are being perceived, even if it is not the way they were originally intended to be.

Chapter 2 - Literature Review

Understanding Color

Color is seen by humans through their eyes as light. Light is reflected from an object into the eye, and the eye interprets the reflected wavelength as a “color.” When all wavelengths are visible, the color seen is white, while black is seen when no wavelengths are visible. Therefore, the more different wavelengths (colors) are added, the more the human eye will perceive white light. Because of this, colors from light are called additive colors. The primary colors used for additive color are red, green, and blue, commonly known as RGB. Tubes in cathode ray tube (CRT) devices such as monitors and televisions are colored red, green, and blue. (Pantone Color Think Tank) They create images by turning on or off rapidly.

However, in print, the primary colors used are cyan, magenta, yellow and black, known as CMYK. If cyan, magenta and yellow are added together, the result is close to the color black. In printing, black is added to create a true black. If they are subtracted from the substrate, the result is white, as they no longer act as filters and white light is allowed through to reflect off the substrate. Therefore they are referred to as subtractive colors (Pantone Color Think Tank).

Understanding Color Management

Color management is a key component to consistent images. Machines interpret and display color using software that may not be the same for every machine. This is called device dependent color (Aguilera). Color management attempts to reconcile these differences. The International Color Consortium (ICC) is the authority on color management and sets color standards. The organization was established in 1993 by five companies, Adobe Systems Inc, Apple Inc, Agfa-Gevaert N.V, Eastman Kodak Company, and Microsoft Corporation, to promote

an effective and standardized color management system that could be used by all (ICC). Their definition of color management is “A system that transforms data encoded for one device (such as scanner RGB) into that for another device (such as printer CMYK) in such a way that it reproduces on print the same colors as those scanned.” The goal is to keep the appearance of images as uniform as possible.

This is achieved using ICC color profiles. Profiles are used to describe an image by defining a color space that encompasses all the colors in that image. These color spaces can vary greatly depending on the device used to create the image and the type of media the image will be used in. Color profiles provide a set of instructions for a computer to interpret the color. Without profiles, the computer will interpret the color according to a default setting and the resulting image probably will not match what the artist saw and approved on a different computer. These color variations are actually quite common on the Internet, as many images are .JPG files without embedded profiles. The most common color space on the Internet today is sRGB. sRGB is the color space most commonly found on consumer level point-and-shoot cameras. The color gamut is appropriate for older monitors, as the color space was defined in 1996 (ICC). Adobe RGB is also a popular color gamut. It is much larger than sRGB and is preferred for print production and professional photography work because its rich colors can be displayed both on a high quality monitor and in print. Numerous other color gamuts exist, such as ProPhoto RGB, which is much larger than both sRGB and Adobe RGB 1998. It was developed by Eastman Kodak, and is also known as ROMM RGB (Spaulding).

Displaying images in the correct color gamut is essential. Opening an image in the wrong color gamut can result in colors that are not accurate. Skin can become pink or sallow. Grass can

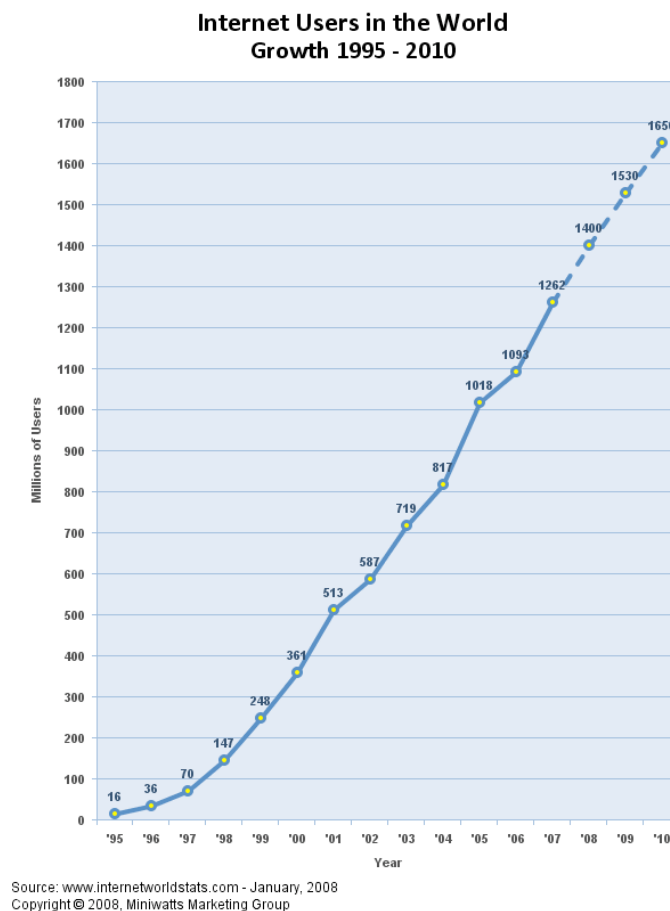
become unrealistically green and blue skies can nearly look overcast. Color profiles describe the limits of color information within an image according to their own boundaries. Applying a gamut that is too large will create colors that are much warmer than was intended. A gamut that is too small will result in images that are not warm enough. The correct color gamut will display the colors in a photograph as they were captured. The photographer should edit the photograph in the color gamut that the photo was created in. Therefore it is not necessarily better to convert an sRGB profiled photograph into a larger Adobe RGB workspace.

It is also essential for those working in the graphic arts to calibrate their monitors using a device such as a spectrophotometer. The Color Munki by X-Rite can also profile projectors in addition to monitors and printers. It is important to know when a monitor is out of calibration as it will affect how an image is displayed. It is recommended to calibrate a monitor at least once a quarter, or once every three months (Aguilera).

Web Browsers

A Web browser is a program used to navigate the Internet. It is one of the most commonly used programs on a computer. A browser allows the user to explore everything the Web has to offer, including games, news, and images. Initially, Web browsers were text only and did not incorporate graphics. The modern Web browser was created in 1992 by Marc Andreessen and Eric Bina, graduate students of the University of Illinois-Champaign Urbana. It was called Mosaic and was released in January of 1993. Graphics were not originally intended to be part of Mosaic, as Bina stated “I was afraid that they would use big ones that would waste a lot of bandwidth.” This was fostered by the creation of the .JPG format, created by the Independent JPG Group, as well as the creation of the Graphics Interchange Format (known as .GIF). .GIF

images have a color gamut of 216 colors which cannot accurately reproduce tones, .JPG images are commonly used for photographs. As services such as Photobucket and Yahoo's Flickr have made it easy for users to share photos with others, the Internet is now plentiful with large images for the whole world to browse. As seen in Figure 1, the number of people using the Internet has also grown in astounding numbers.



(Figure 1)

The predominant Web browser used today is Microsoft's Internet Explorer with all of its versions amounting to about 54 percent of the Web browser market (Schonfeld). Internet Explorer was first released in 1995 and has gone through several versions since, with Internet Explorer 8 being the most recent edition. Previous versions of Internet Explorer have

more market share than other stand alone browsers have. However, the ability to color manage only became available in Internet Explorer 7, a fairly recent version of Internet Explorer that was released in 2006. The ability to color manage is optional and the user must enable it in their preferences. As a default, color management is turned off.

Mozilla Firefox is another popular browser with 27.6 percent of the market. (Schonfeld) It is an open source Web browser, which means that users can program and code their own additions and custom versions of the browsers. Prior to Firefox 3, color management was not an available option. In the Firefox 3 Alpha 7 release from August 2007, it is possible for Firefox to recognize embedded color profiles (Cabello). However it is not a default option on a PC. The user must turn it on by enabling an extension called an add-on. Firefox is available for both Macintosh and Windows users, and is popular on both.

Apple's own Safari browser is the only browser on the market that has color management turned on by default. Safari has done so since its first release in 2003, according to the Apple website. Both the Macintosh and Windows versions of Safari have color management enabled. It does not color manage images that do not have embedded color profiles and displays those images according to the system default profile. Safari is the standard browser included on all Macintosh computers, and has been available for Windows users as of 2007. However, its market share is only four percent. (Schonfeld) Google's Chrome browser also has four percent of the market, but does not support embedded color profiles at all. According to an article by C-Net, Mark Larson, the Chrome Program Manager, has said "I don't see how any sites could depend on this feature if it's missing/disabled for 90 percent of users. I'm all for it, but it's definitely not a release priority" (Shankland). The reason for not including color management is Chrome's goal

to be a high performing browser with high speeds. Embedded color profiles take longer to load, since they require processing by the browser.

For the time being, most Web browsers are not, as a default, set to be able to use embedded color profiles. The average consumer is not aware of color management and for them, it is not a priority to have it turned on. However, for professionals working in the graphic arts, entertainment, and media industry, color management on the Internet is very important. Publications often find their stock photography online. It is important for them to receive exactly the photo they think has been purchased.

Chapter 3 - Research Methods and Procedures

To determine the best way to color manage images for various web browsers, I will research using the Scientific Method. Content Analysis will then be used to create a final recommendation to solve the problem and an understanding of the nature of color management on the Internet.

The Scientific Method is a procedure that tests hypotheses and theories to gain knowledge and reach tentative conclusions and results. A question or hypothesis must be posed to define the problem. Then a hypothesis is formed and tested by collecting and analyzing data. After a conclusion is drawn, the research must be repeated to verify the result (Levenson 19). I will use the Scientific Method to find the optimal methods to ensure the color quality of images can be optimal in every browser. In order to obtain images for testing, I will use an Olympus E-500 camera. The images will be shot in Olympus's native Raw file format with an Adobe RGB color profile applied in the camera, allowing for optimal image editing. I will use Adobe Photoshop to edit these photographs according to my artistic preferences and save one with the original Adobe RGB profile, and another with no profile at all. I will then view the images on two computers. On both of computers, I will first view the color managed image, and the non-color managed image, in Photoshop side by side. The first will be a Macintosh computer in the Electronic Publishing Lab in the Graphic Arts building. I will open the image in Safari, then Firefox and Chrome and will use Mac's included DigitalColor Meter to observe changes in color data in each browser window. This will allow me to see any differences between the images displayed in each browser. The process will be repeated on a PC computer running Windows 7 in the PC Lab in the Graphic Arts building using Internet Explorer 8 and the Windows version of

Firefox, as well as Chrome and Safari for Windows. Using screenshots of these browsers, I will then use the DigitalColor Meter to measure the images from the PC against those viewed on a Macintosh computer. I will also observe which images looks best to me, the artist. Since that is a subjective opinion, I will also be using an iSis RGB 918 target, which has many color swatches that can be measured with the DigitalColor Meter. Each swatch has a color value that is specified in an included text file. If a swatch is measured to be different from the specified color value, it will mean that the browser software is interpreting the color differently than it is supposed to, showing the variations between each browser. The iSis target will provide an objective, measurable view of the differences in browser software.

Content Analysis will used to better understand the results of the experiment. With this method, I will use the knowledge gained to determine the best methods for color managing images for different browsers and computers. This can include what the best color profile is and what kind of browser and computer should be used. For my experiment, I will create a chart of all the different combinations of computer systems and color profiles to determine which method is optimal for color management. I will then be able to create recommendations for professionals in the graphic arts industry to achieve optimal image quality for their work displayed online.

Chapter 4 - Results

Throughout the research, I encountered certain variations that must be considered. When saving the screenshots of the browser windows, there was an inconsistency in the file type that I was allowed to save the screenshot as. On Windows, the Snipping Tool saves the images as .PNG files. On a Macintosh, the Grab tool saves the images as .TIFF files. As both file formats are non-lossy and do not damage the image, the choice between the two file formats should not affect the color values.

For the research, I used an image I had taken of a friend, Jaimie. I chose this image because of the noticeable difference in the color of part of Jaimie's shirt, which is a vibrant red. In the image that has been profiled with an Adobe RGB 1998 profile, which is the profile used in my camera, the red is very vibrant and accurate to the actual shirt. In the image that does not have a color profile, the red is duller and darker. Her skin tone also changes and becomes duller in the image with no profile.

I first viewed the both images in Photoshop on both the Macintosh and the PC. This is used as the control group, because Photoshop uses the color profile or lack thereof to display the image accurately. Photoshop is the tool used by photographers to edit an image to their preferences. The image viewed in Photoshop is what the photographer intends for the world to see. As can be seen in the images, the image on the right, which has no profile, is slightly less vibrant than the image on the left, which does have the Adobe RGB 1998 profile.



I then proceeded to open the images in each browser and observed the differences in color and the overall aesthetic appeal of the image. For each browser, I compared the image viewed in the Windows version of the browser to the same image viewed in the Macintosh version of the browser.

(For the complete collection of screenshots from each browser, please refer to Appendix A)

Safari

When viewing the color profiled images in Safari, both the Macintosh and Windows versions looked the same. However, when viewing the image that did not have a color profile, there was a noticeable difference in the red section of Jaimie's shirt. The Windows version of Safari was brighter and looked as if an Adobe RGB 1998 profile had been applied to it, though it was not as vibrant as it was in Photoshop.

Firefox

Both sets of images in Firefox looked as they did in Photoshop. There were no noticeable differences in the color of the skin tone or the shirt.












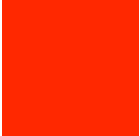


Chrome



When viewing the color managed image in Chrome, there were noticeable differences. The Macintosh version of Chrome displayed the image with a color profile, so the image looked as it did in Photoshop. However, the Windows version of Chrome did not. The color profiled image looked the same as the non-profiled image.

However, when viewing the image that did not have a color profile, the results were the opposite. The Windows version of Chrome displayed the image with colors similar to the image with a Adobe RGB 1998 color profile. However, the Macintosh version of Chrome did not.

Internet Explorer

Despite the fact that a version of Internet Explorer for the Macintosh operating system does not exist, I was curious to see what my images would look like in Internet Explorer, since it is the browser with the greatest market share. When the color managed image was viewed in Internet Explorer, the colors were dull and looked like the image with no profile. However, the image with no profile looked richer than the image with a profile.

	Firefox (W)	Firefox (M)	Chrome (W)	Chrome (M)	Safari (W)	Safari (M)	Internet Explorer (M)
With Profile							
Without Profile							

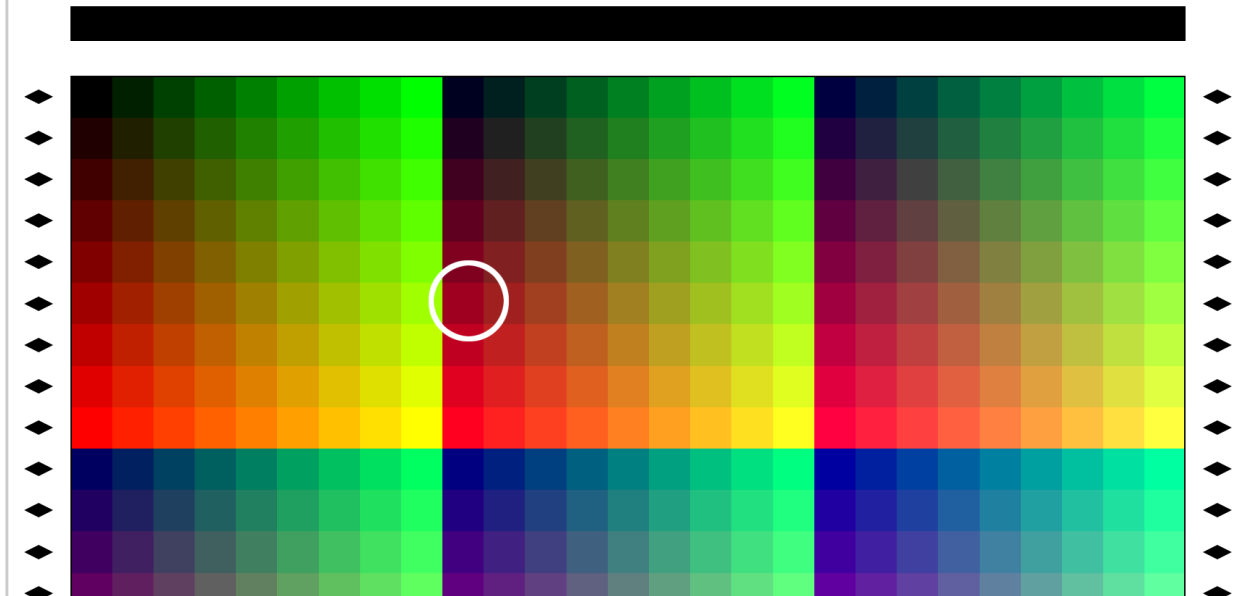
 = correctly displayed  = incorrectly displayed

iSis Targets

For the next part of the experiment, I opened the iSis target in Photoshop on both the Macintosh and PC computers to use as a control group. I then used the DigitalColor Meter to measure a particular spot on the iSis target, a deep red, shown below.

(For screenshots of the iSis Target in different browsers, refer to Appendix B)

RGB 918 Eye-One iSis Target by Bill Atkinson



When measured in Photoshop, the RGB value for the color swatch is 160-0-32, which is the correct value listed for the color swatch. It is the same for Photoshop on both the Macintosh and Windows operating systems. I then opened the iSis target in each browser, captured a screenshot, and measured the selected color swatch with the DigitalColor Meter.

Browser	R	G	B
Safari (Macintosh)	147	16	20
Safari (Windows)	142	0	24
Chrome (Macintosh)	147	16	20
Chrome (Windows)	142	0	24
Firefox (Macintosh)	147	16	20
Firefox (Windows)	142	0	24
Internet Explorer (Windows)	142	0	24

As observed, none of the color values match the true RGB value of the color swatch.

However, the color values are consistent for each operating system. Out of curiosity, I opened the iSis target in Safari on a Macintosh and measured the color swatch without taking a screenshot.

The measured values were the correct values listed for the target.

Chapter 5 - Conclusions

The results of this experiment were perplexing to me. Many observations that I made did not make sense.

The differences between the photographs viewed in web browsers, though mostly consistent with what I expected, did have some unexpected variations. Chrome, in particular, defied what was stated in the literature review, and applied some sort of color management in Windows to an image that had no color profile. I theorize that the Windows and Macintosh versions of Chrome, as well as the other browsers, have not been programmed consistently. Perhaps there are different teams of software engineers that create the browser for each operating system. There are, after all, differences in functionality, options, and appearance in each browser for each operating system. Though each version shares basic characteristics, small differences in the programs can affect how images are displayed. The differences in settings for displays in the Macintosh and Windows operating systems could also affect the way browsers display images. An image displayed in a browser must be interpreted through the browser, as well as through the operating system's display settings. It is as if an image is being viewed through two lenses instead of one, which could distort how the image is displayed.

The inconsistency between the screenshot and the actual displayed iSis target could also be explained in this way. Because the screenshot first has to be converted into a file, a .PNG or a .TIFF, it could be interpreted differently than the way it was originally viewed.

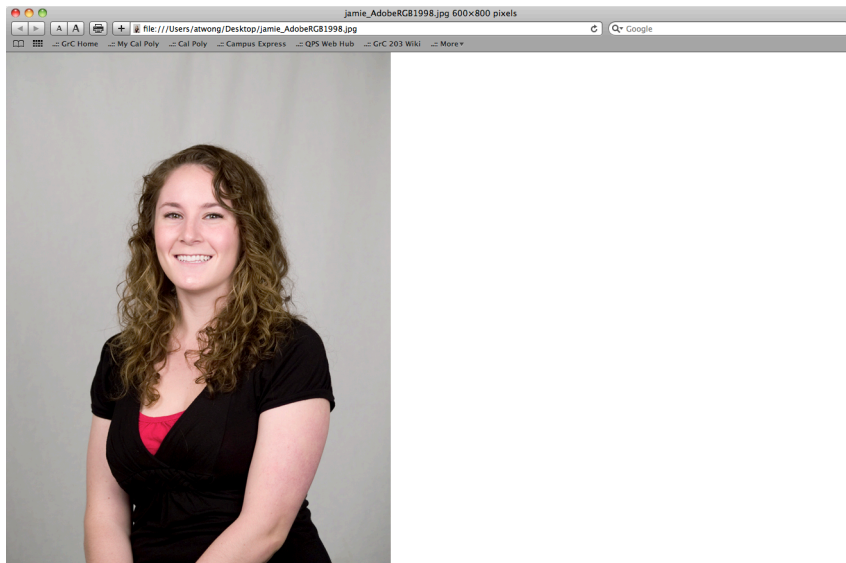
From my observations and personal preference, Mozilla Firefox appeared to be the best browser for displaying images accurately. While the other browsers ignored the color profiles, or interpreted them incorrectly, Firefox displayed the images as they appeared in Photoshop in both

operating systems. Since Firefox is the second most popular browser, with 27.6 percent market share, it would be the most beneficial for photographers to use Firefox to see how their images would be displayed online. Because it recognizes color profiles and interprets them accurately for both operating systems, Firefox seems to be the most logical choice for artists, photographers, those working in the graphic arts industry and buyers of images. As its market share continues to grow, more and more people will be able to see color accurate images.

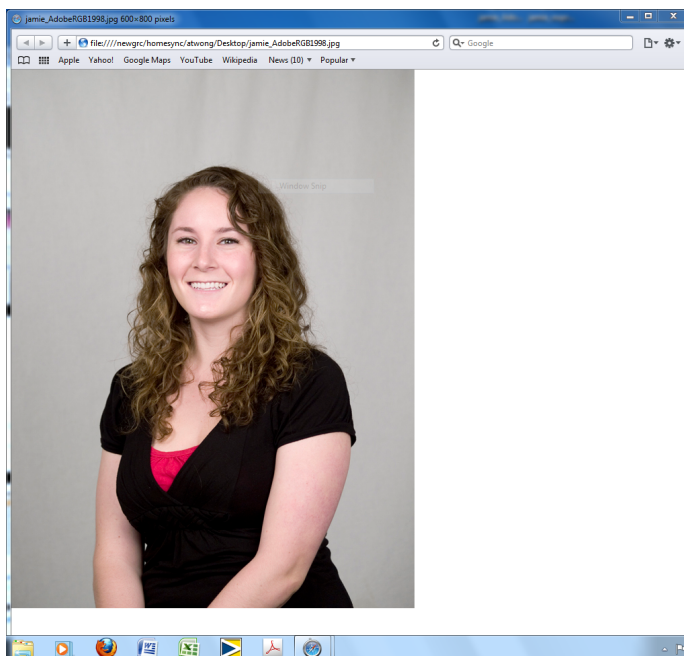
I would also recommend the use of color profiles in all photographs and images posted in the Internet. Though some browsers may ignore them for now, the trend in web browsers is heading towards allowing color management. With inevitable improvements in Internet speeds and computer processors, color profiles will no longer be a threat to browser performance in the future. For an artist and those in the artistic community, quality should be first and foremost when displaying and viewing their work. By imbedding profiles in their images, artists can ensure that those in the audience with browsers that accept color profiles will see their work as they have intended.

My experiment and analysis are by no means an authoritative conclusion on color management for browsers. However, it does provide valuable information that I will now use in everyday life and is a step towards improving how viewers on the Internet see my work. Color management on the Internet is still an immature subject, and there is much more research and work to be done as more browsers start to support color management. There is no way to guarantee your images will look the way you expected on a friend's computer, but as technology improves and more artists recognize the value and exposure that the Internet provides them, color management for web browsers will become much easier to control.

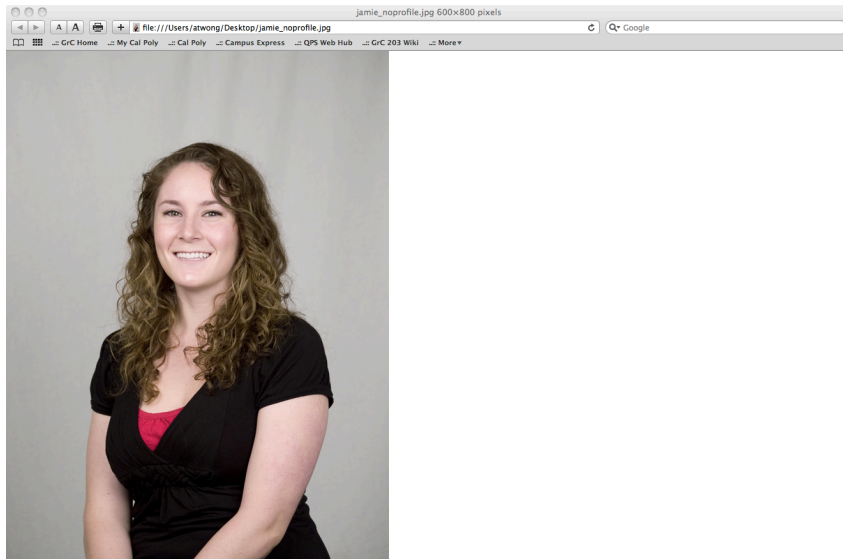
Appendix A - Photographs



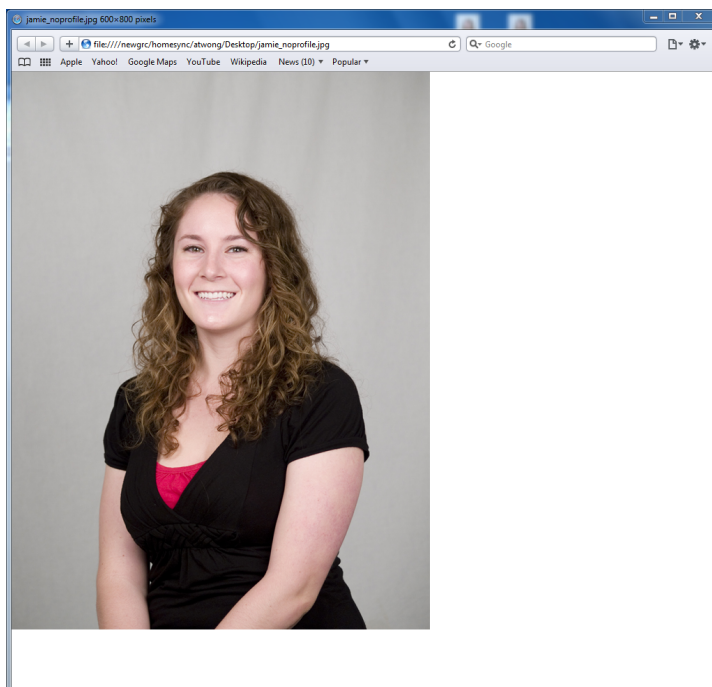
Safari on Macintosh - Adobe RGB 1998 Profile



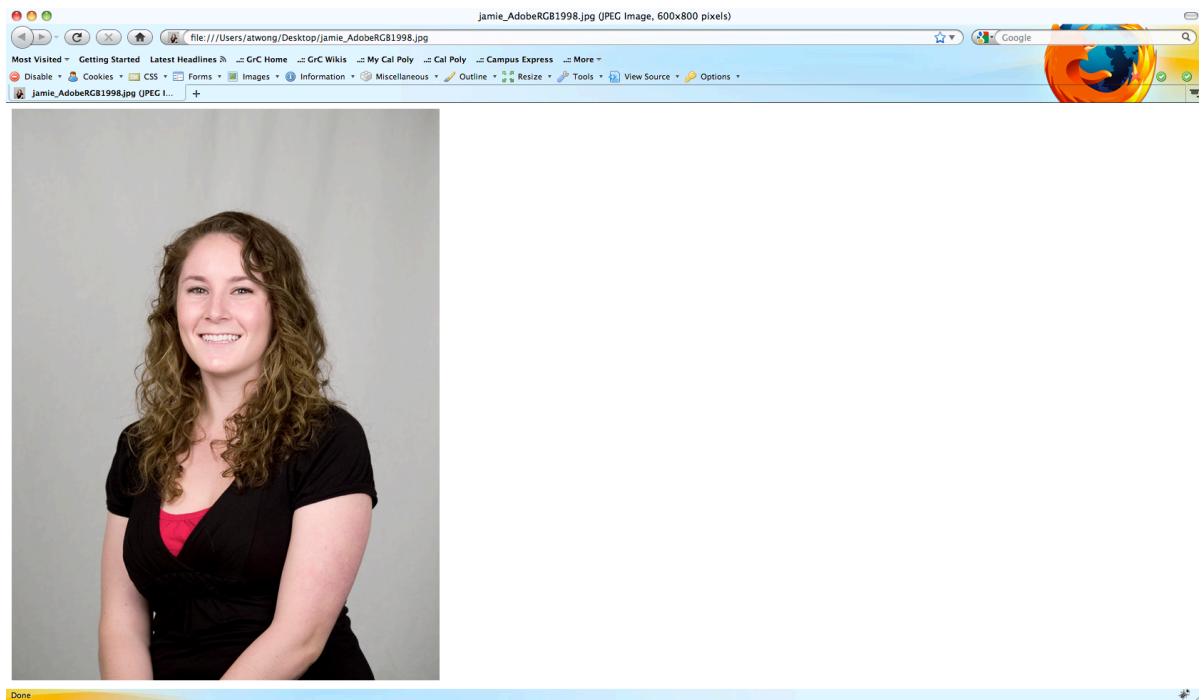
Safari on Windows 7 - Adobe RGB 1998 Profile



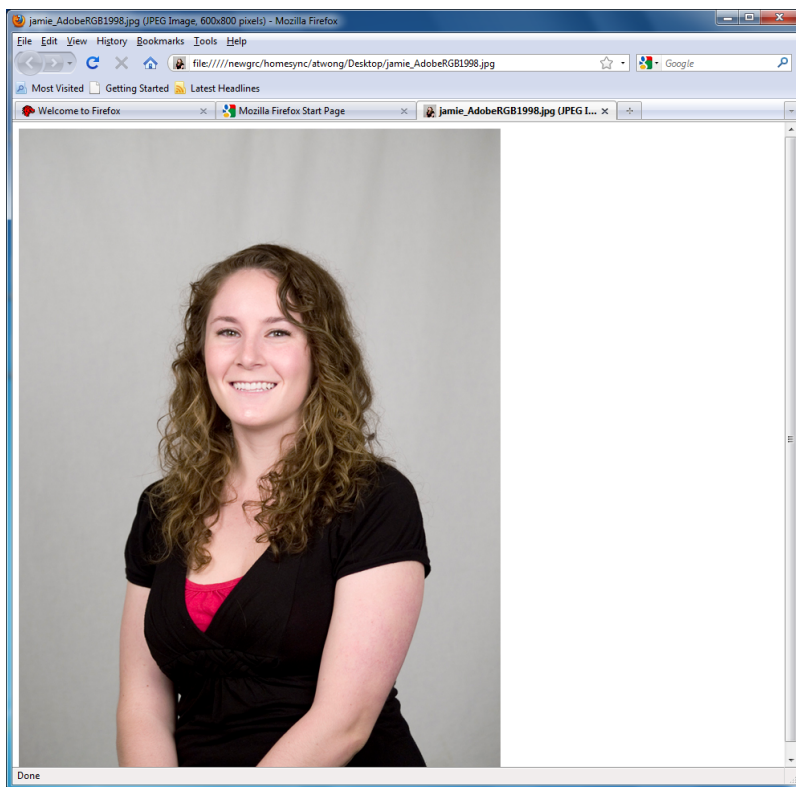
Safari on Macintosh - No Profile



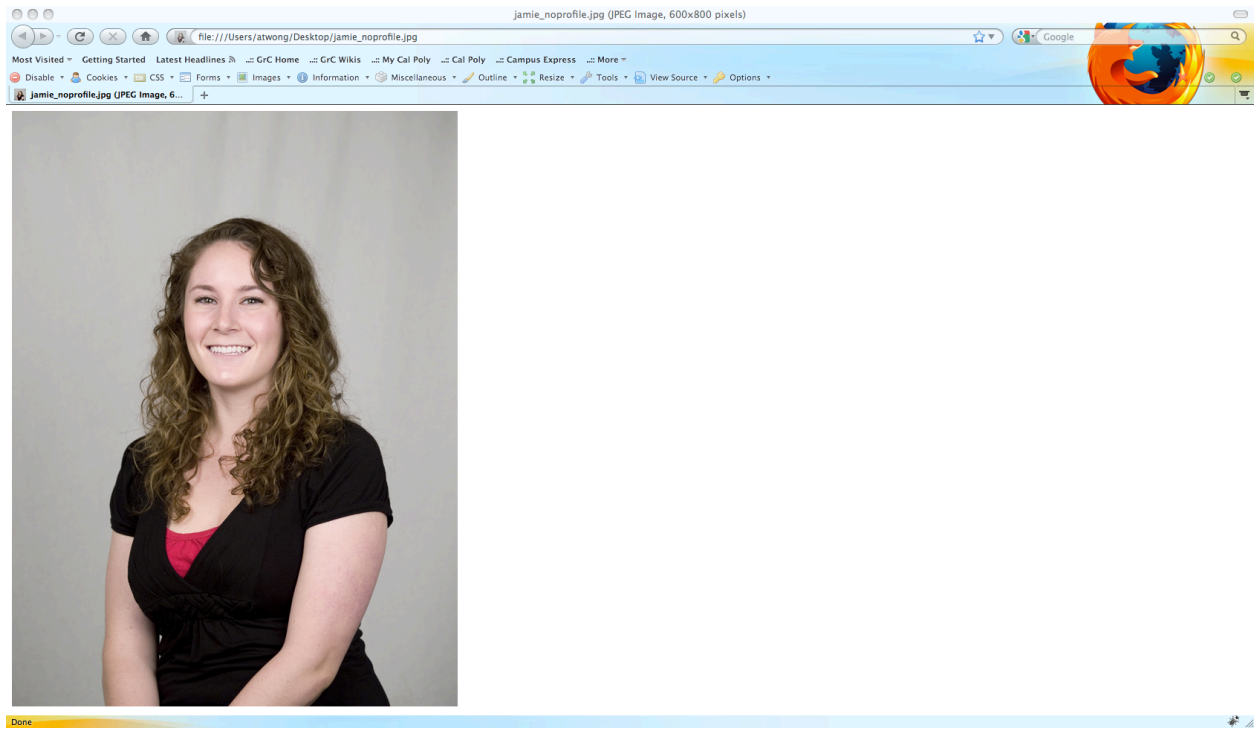
Safari on Windows - No Profile



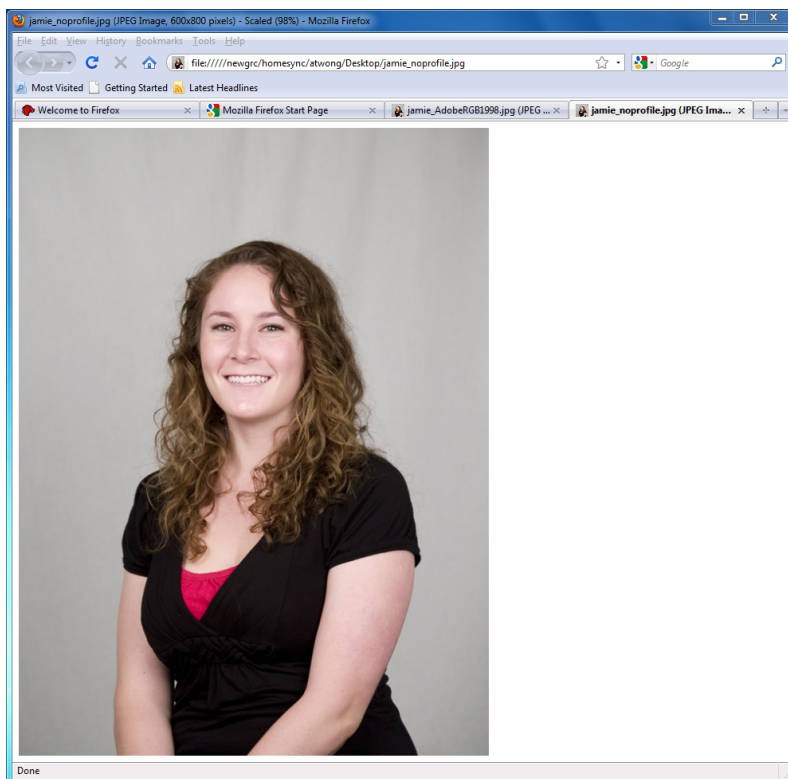
Firefox on Macintosh - Adobe RGB 1998 Profile



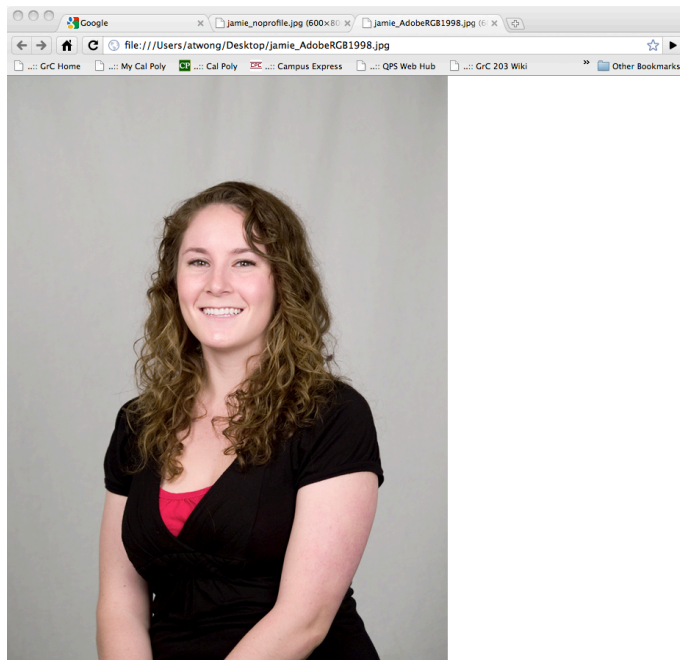
Firefox on Windows - Adobe RGB 1998 Profile



Firefox on Macintosh - No Profile



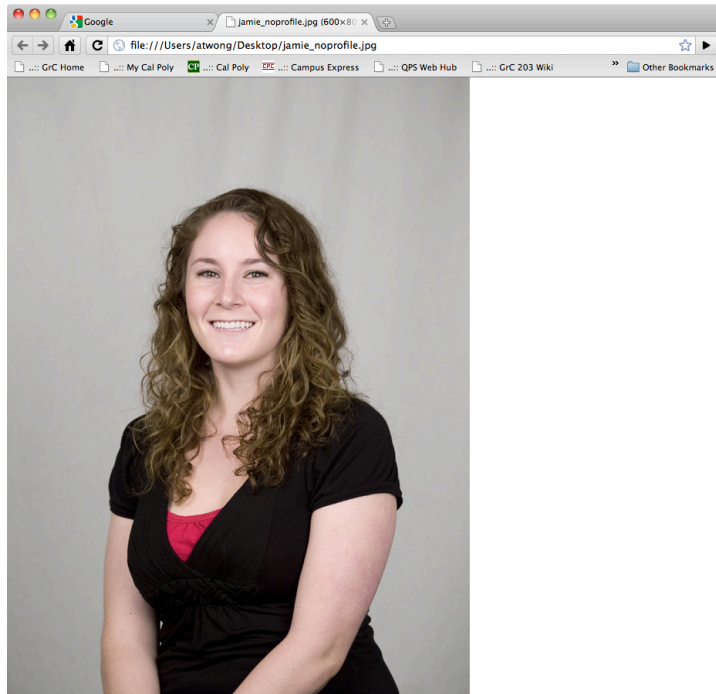
Firefox on Windows - No Profile



Chrome on Macintosh - Adobe RGB 1998 Profile



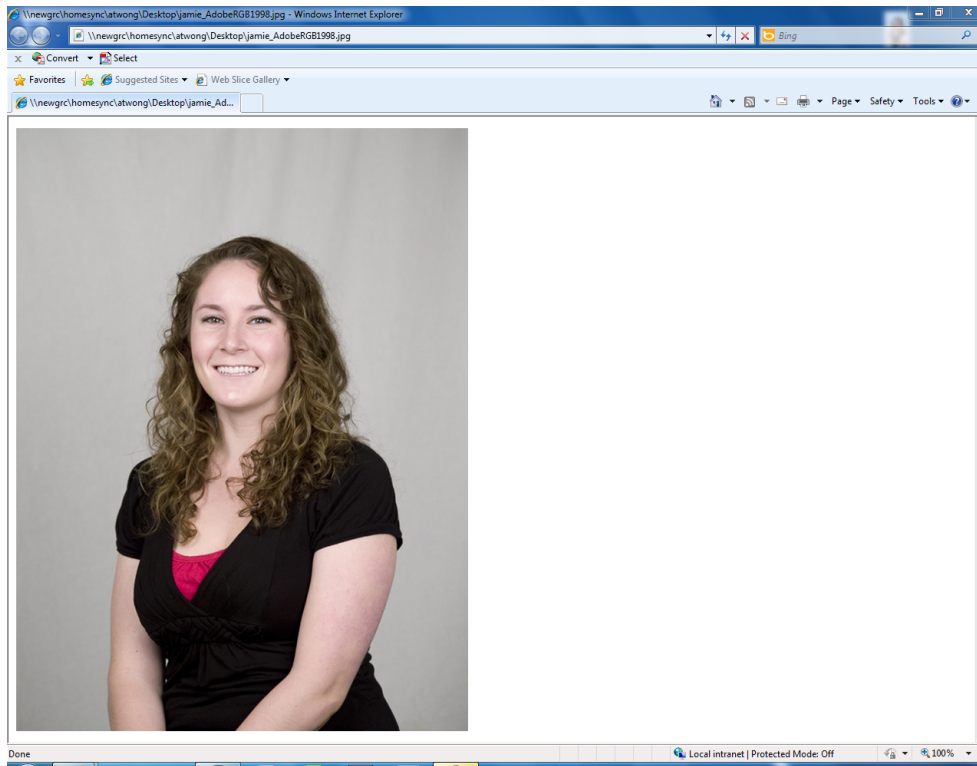
Chrome on Windows - Adobe RGB 1998 Profile



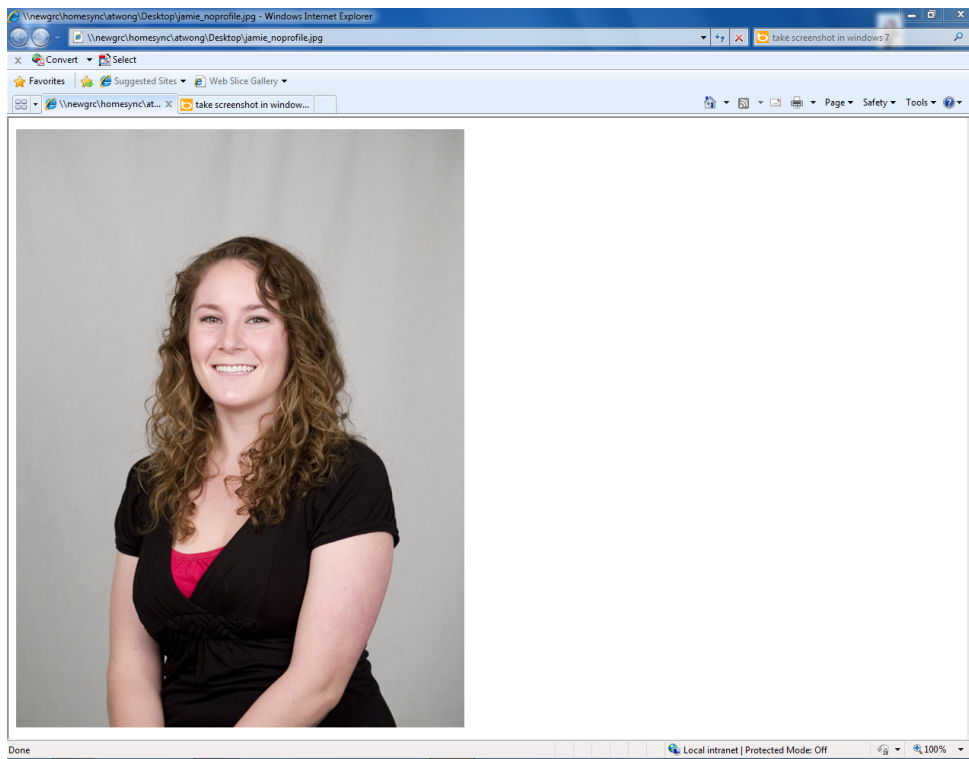
Chrome on Macintosh - No Profile



Chrome on Windows - No Profile



Internet Explorer - Adobe RGB 1998 Profile

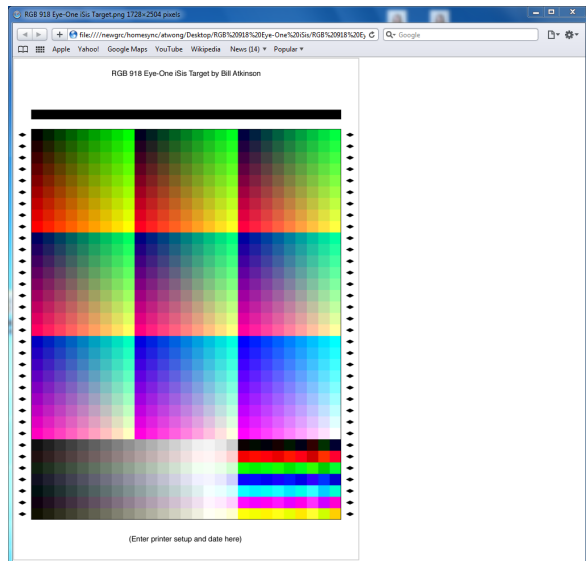


Internet Explorer - No Profile

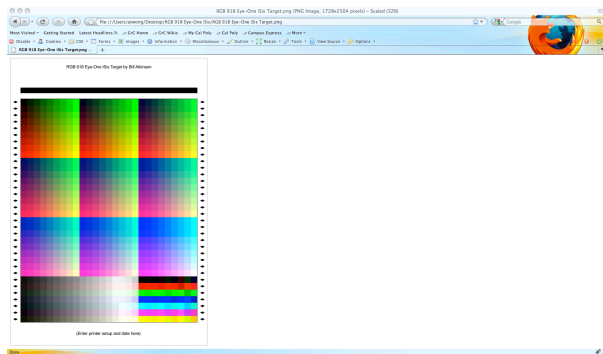
Appendix B - iSis Targets



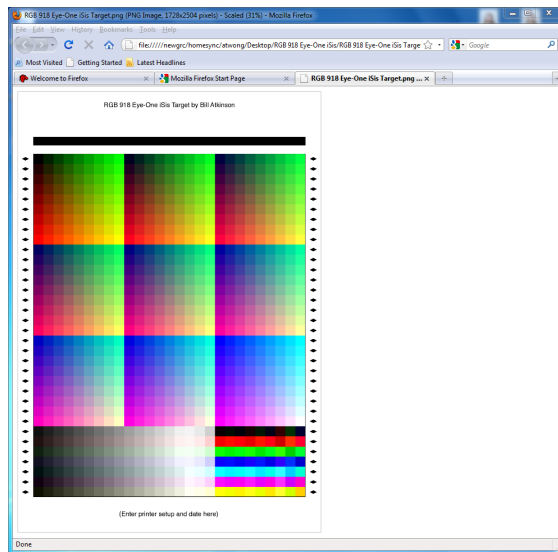
Safari for Macintosh



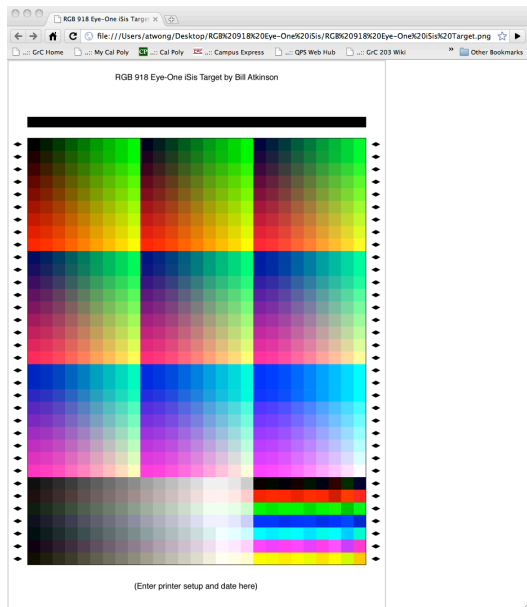
Safari for Windows



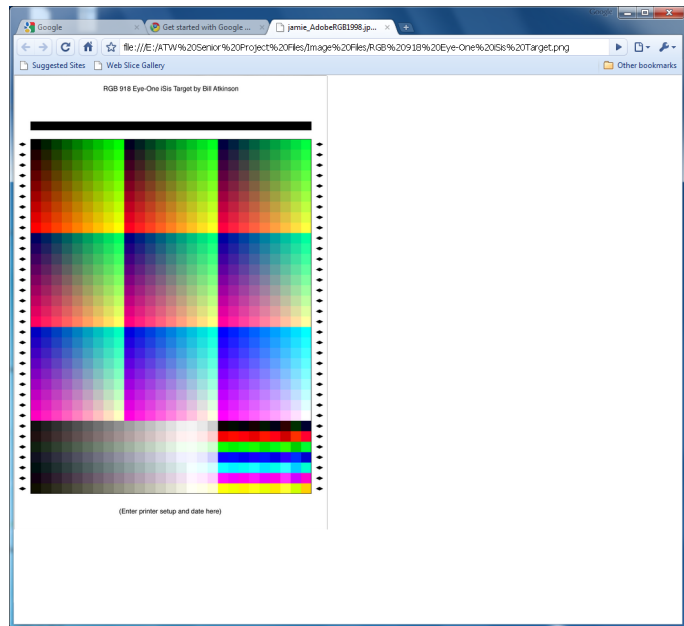
Firefox for Macintosh



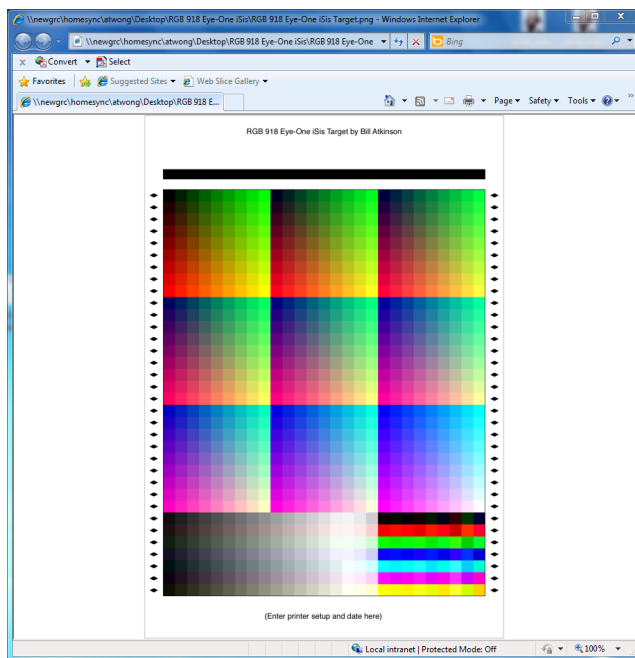
Firefox for Windows



Chrome for Macintosh



Chrome for Windows



Internet Explorer for Windows

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